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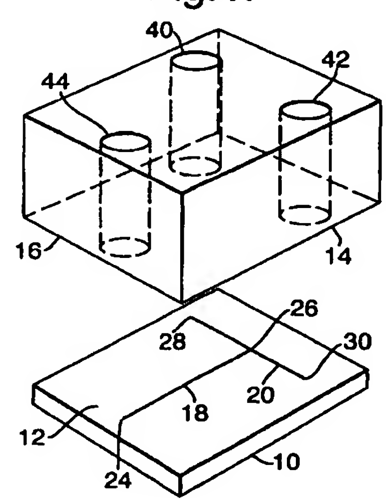
(54) Chemical devices, methods of manufacturing and of using chemical devices

(57) A method of manufacturing a chemical device comprises, providing a first member (10) with a surface portion and a groove (18,20) located at the surface portion, and a second member (14) with a surface portion (16). A coating (34) which may be metallic or organic is provided on either the surface portion of the first or second member. The coating (34) is heated by combined convective heating and microwave irradiation. For a metallic coating (34) the heated coating bonds to the surface portion of the second member (14) so as to close the groove (18,20) to form a channel. For an organic coating the coating heats the surface portions of the two members to a temperature suitable to cause thermal connections. The organic coating then vaporises allowing the surface portions to contact and undergo thermal connection.

A method of controlling hydrostatic and diffusion based flow of a liquid in a chemical device and a method of preparing a working solution of a desired concentration in a chemical device are also described.

Fig.1.



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Description

[0001] The invention relates to chemical devices, methods for manufacturing chemical devices and methods for use with chemical devices.

[0002] The term "chemical devices" is used in this specification to include devices used for performing chemical reactions (including biochemical reactions) and/or for performing analysis and separation of chemical (including biochemical) substances. Such analysis and separation of chemical substances may or may not include performing chemical reactions.

[0003] A known type of chemical device is a chip-type chemical device. A chip-type chemical device is formed from a first member (usually a plate of glass, metal, polymer, silicon or quartz) that has a surface portion and at least one groove (more usually a plurality of interconnected grooves) located at the surface portion, and a second member (usually a block formed of glass, metal, polymer, silicon or quartz) having a co-operating surface portion. The surface portions are connected together such that the groove (or the plurality of interconnected grooves) is closed to form a channel (or a plurality of interconnected channels). Reagents and other chemical substances may be passed through the channel (or the plurality of interconnected channels) in a controlled manner so as to perform chemical reactions, or analysis or separation of chemical substances.

[0004] For most purposes, the current preferred method of connecting the surface portions of glass members is by heating the members to a temperature close to their upper annealing temperature while the surface portions are contacting one another. This results in direct thermal connection (also called thermal bonding or annealing) of the surface portions - that is to say direct thermally induced bonding together of the surface portions without any intervening link or extraneous adhesive.

[0005] In accordance with a first aspect of the invention, there is provided a method of manufacturing a chemical device comprising, providing a first member with a surface portion and a groove located at the surface portion, a second member with a surface portion, and means heatable by electromagnetic irradiation, positioning the members and the means so that the means lies between the surface portions, and heating the means by electromagnetic irradiation to effect or assist linking of the surface portions by the means so as to close the groove to form a channel.

[0006] In accordance with a second aspect of the invention, there is provided a method of manufacturing a chemical device comprising, providing first and second members having respective surface portions, and means heatable by electromagnetic irradiation, positioning the members and the means relative to one another so that the means is positioned for providing localised heating of at least one of the surface portions on heating of the means by electromagnetic irradiation, irradiating with electromagnetic radiation so as to cause said localised heating, and connecting the surface portions together so that the surface portions cooperate to define a channel, the localised heating effecting or assisting said connection.

[0007] According to a third aspect of the invention, there is provided a chemical device comprising a first member with a surface portion and a groove located at the surface portion and a second member with a surface portion, the surface portions being linked by an electromagnetic irradiation heatable layer such that the groove is closed to form a channel.

[0008] According to a fourth aspect of the invention, there is provided a method of controlling liquid movement in a chemical device comprising a porous structure, the method comprising applying an electrical potential to generate an electroosmotic force in the porous structure so as to propel a liquid through the porous structure, and using the porous structure to resist or prevent flow of a liquid through the porous structure in response to hydrostatic force.

[0009] Controlling the flow of liquids in this way may be used to reduce or prevent undesired flow and mixing of liquids due to hydrostatic force.

[0010] According to a fifth aspect of the invention, there is provided a method of preparing a working solution of a substance at a desired concentration in a chemical device comprising, providing a substance in a soluble form in a chemical device, contacting the substance with a solvent for the substance in the device, and controlling said contact between the substance and the solvent so as to produce a working solution of the substance in the solvent at a concentration dependent on said control.

[0011] The ability to prepare working solutions of a desired concentration in this way may be useful when it is not practicable to introduce externally prepared working solutions into the chemical device. This may be of utility in applications such as environmental monitoring, where chemical devices are required to perform monitoring operations repeatedly over some length of time without external maintenance.

[0012] The following is a more detailed description of embodiments of the invention, by way of example, reference being made to the appended schematic drawings in which:-

Figure 1 shows a first stage in the manufacture of a chip-type chemical device;

Figure 2 shows a second stage in the manufacture of the device;

Figure 3 is a cross-sectional view (not to scale) of the completed device;

Figure 4 is a cross-sectional view of a second chip-type chemical device;

Figure 5 is a schematic representation of a first embodiment of a method of preparing a working solution;

Figure 6 is a schematic representation of a second embodiment of a method of preparing a working solution; and

Figure 7 is a schematic representation of a third embodiment of a method of preparing a working solution.

Method 1- method of manufacturing a chip-type chemical device

[0013] Referring to Figure 1, the chip-type chemical device is formed from a plate 10 of borosilicate glass having a smooth, upper, planar surface 12 and a block 14 of borosilicate glass having a smooth, lower, planar surface 16.

[0014] First and second grooves 18,20 are formed in the planar surface 12 of the plate 10. The grooves 18,20 are formed by coating the planar surface 12 with chromium and photoresist, and then using photolithography and wet etching. The process is described in the journal *Analyst*, January 1997, 122(1R-10R).

[0015] The first groove 18 has first and second ends 22,24. The first end 22 of the first groove 18 meets the second groove 20 at a junction 26 that lies intermediate first and second ends 28,30 of the second groove 20 so that the first and second grooves together form the shape of a T. Each groove 18,20 is approximately 300 μm wide and 115 μm deep.

[0016] After the formation of the grooves 18,20 the remaining chromium and photo-resist are removed. This is done by, firstly, exposing the plate 10 to strong ultraviolet light for one to two hours before dipping the plate 10 in photoresist remover for two to three hours. The plate 10 is then rinsed with water and any remaining photoresist and chromium are removed using Microposit Chrome Etch 18.

[0017] A portion of the planar surface 12 of the plate 10 is then provided with a coating 34 of chromium. The coating 34 (and also the portion) extends, as a relatively narrow strip, around the T shape formed by the two grooves 18,20, as shown in Figure 2. Hence, the coating 34 does not cover the whole of the surface 12. The coating 34 is formed by first covering the whole planar surface 12, and also the inner surfaces of the grooves 18,20, with a layer of chromium. The chromium is then coated with photoresist and the photoresist and the chromium are then removed from the internal surfaces of the grooves 18,20 and the regions of the planar surface 12 where chromium is not required using standard photolithography and removal methods.

[0018] Finally, the remaining photoresist is removed to leave the desired chromium coating 34.

[0019] As an alternative to forming the chromium coating 34 as described above, an identical chromium coating may be formed from the chromium used during the formation of the grooves 13,20. The chromium remaining after the formation of the grooves 18,20 (which covers the whole surface 12 of the plate 10 but not the surfaces of the grooves) is, instead of being totally removed as described above, removed selectively so as to leave chromium covering the portion (as described above with reference to Figure 2) of the surface 12 of the plate 10.

[0020] A micro-porous silica structure 36 is then produced so as to fill a region of the first groove 18 that extends from the first end 22 of the first groove 18 to a point near the second end 24 of the first groove 18 (see Figure 2). The silica structure 36 fills the whole volume of the groove 18 in the region and also extends slightly above the groove 18 so as to fill the space lying between the portions of the coating 34 disposed at either side of the region.

[0021] The silica structure 36 is produced as follows. A solution of formamide (10% v/v), and potassium silicate (21% SiO_2, 9%K_2O, Prolabo) is prepared at room temperature. The solution is mixed for 30 seconds using a glass rod and allowed to stand for an additional two minutes. Blu-Tac (trade mark) plugs are pressed into the grooves 18,20 at either side of the region that is to receive the silica structure 36. The solution, having stood for the two minutes, is then mixed with silica bonded catalyst and introduced into the region of the first groove 18 between the Blu-Tac plugs. The solution is added until it reaches the top of the coating 34.

[0022] The plate 10 is then heated to 100°C for one hour during which the solution solidifies to form the micro-porous silica structure 36 containing the silica supported catalyst. The micro-porous silica structure 36 is then washed with a $2x10^{-2}$mol dm^{-3} solution of disodium tetraborate buffer in order to remove unreacted reagent.

[0023] The block 14 is then prepared by drilling first, second and third cylindrical holes 40,42,44 through the planar surface 16 and through the block 14, as shown in Figure 1. The axes of the holes 40,42,44 have the same relative spacing as the first and second ends 28,30 of the second groove 20 and the second end 24 of the first groove 18.

[0024] The planar surface 12 of the plate 10 is then linked to the planar surface 16 of the block 14. To do this, the block 14 is placed over the plate 10 such that the planar surfaces 12,16 face one another and are separated by the chromium coating 34. The axis of the first hole 40 passes through the first end 28 of the second groove 20, the axis of the second hole 42 passes through the second end 30 of the second groove 20, and the axis of third hole 44 passes through the second end 24 of the first groove 18.

[0025] The plate 10 and the block 14 are then positioned, in the orientation described above, in the heating cavity of a microwave furnace (CEM Microwave Ashing

System 300), which is subsequently operated. The microwave furnace heats by microwave irradiation and by convective and conductive heating. However, the microwave irradiation causes the chromium coating 34 to heat more quickly than the borosilicate glass of the plate 10 and the block 14. This is because the chromium has a higher tan δ ratio than the borosilicate glass for the microwave frequency used (the tan δ ratio = ε"/ε'. Where ε" is dielectric loss - a measure of the efficiency with which absorbed microwave radiation is converted into heat, and ε' is dielectric constraint - a measure of the ability of a substance to be polarised in the electrical field of a microwave).

[0026] Heating is continued until the chromium coating 34 reaches a temperature at which the chromium coating 34 bonds to the overlying portion of the planar surface 16 of the block 14. This will occur when the chromium coating 34 is near the upper annealing temperature of the borosilicate glass of the block 14. The portion of the planar surface 12 on which the coating 34 is provided and the overlying portion of the planar surface 16 of the block are heated by the chromium coating 34. However, elsewhere, the plate 10 and the block 14 are at significantly lower temperatures.

[0027] Once the chromium coating 34 has bonded to the overlying portion of the planar surface 16 of the block 14 the plate 10 and the block 14 are allowed to cool slowly so as to avoid cracking.

[0028] Hence, in this method, the chromium coating 34 links portions of the planar surfaces 12,16.

[0029] The completed chip-type chemical device is shown in Figure 3 (in which the depth of the coating 34 is exaggerated for clarity). The linking of the portions of the planar surfaces 12,16 by the chromium coating 34 results in the first and second grooves 18,20 being closed to form, respectively, first and second interconnecting channels (the first channel shown at 46, the second channel not shown). Each channel 46 is defined by the corresponding groove 18,20, together with adjacent regions of the chromium coating 34 and the planar surface 16 of the block 14. Hence, the two channels 46 interconnect at the junction 26 and the second channel (corresponding to the second groove 20) has a first portion (not shown) that extends from the junction 26 to the first end 28 of the second groove 20 and a second portion (not shown) that extends from the junction 26 to the second end 30 of the second groove 20.

[0030] It will be appreciated that the silica structure 36 fills the volume of the first channel 46 at the region where it is situated.

[0031] The first, second and third holes 40,42,44 form respective reservoirs that (with the exception of communicating with the channels 46) are closed at the planar surface 16 of the block 16 by the chromium coating 34. Hence, the reservoir formed by the first hole 40 communicates with the first portion of the second channel at the first end 28 of the second groove 20. The reservoir formed by the second hole 42 communicates with the second portion of the second channel at the second end 30 of the second groove 20. The reservoir formed by the third hole 44 communicates with the first channel 46 at the second end 24 of the first groove 18.

[0032] Linking of the plate 10 and the block 14 as described above is advantageous over connection by conventional thermal connection. Firstly, as the linking is effected while the plate 10 and the block 14 are, for the main part, at significantly lower temperatures than those required for conventional thermal connection, the time required for linking and cooling may be significantly less than that required for conventional thermal connection and cooling. Secondly, conventional thermal connection has a high failure rate - it is common for connection to be incomplete, especially in the region of the grooves 18,20. This problem may be ameliorated by linking using the chromium coating 34.

<u>Method 2 - method of manufacturing a chip-type chemical device</u>

[0033] The second method is used to manufacture a second chip-type chemical device (shown in Figure 4). Components used in the second method that are common to the first and second methods are not described in detail below and, to the extent that they are shown in Figure 4, are given the same reference numerals as those used above in respect of the first method.

[0034] The second chip-type chemical device is formed from a plate 10 and a block 14 identical to the plate 10 and the block 14 of the first method. First and second grooves 18 (second groove not shown) are formed in the planar surface 12 of the plate 10, as described for the first method. The first and second grooves 18 have the same configuration as the first and second grooves 18,20 of the first method.

[0035] After the grooves 18 have been formed and the chromium and photoresist remaining from their formation have been removed, as described above, a micro-porous silica structure 53 containing a silica bound catalyst is formed in a region of the first groove 18 that extends from the first end (not shown) of the first groove 18 to a point near the second end (not shown) of the first groove 18. The silica structure 53 completely fills the volume of the first groove in this region, but, unlike the silica structure of the first method, does not extend above the top of the groove 18 (as there is no chromium coating 34). The silica structure 53 is formed in the same way as silica structure 36 of the first method except that the solution is added to the region of the first groove 18 up to the top of the first groove 18 (not up to the top of the chromium coating 34).

[0036] A portion of the planar surface 12 of the plate 10 is then provided with a coating of an organic material (not shown). The coating (and also the portion) extends, as a relatively narrow strip, around the T-shape formed by the two grooves 18 in the same manner as the chromium coating 34 of the first method. The coat-

ing is applied in a conventional manner using masks to prevent coating of the internal surfaces of the grooves 18, of the microporous silica structure 53 and of the regions of the planar surface 12 where coating is not required.

[0037] The organic material of the coating is chosen so that the coating will be heated more quickly than the plate 10 and the block 14 by the microwave radiation used in the microwave furnace - it will have a higher tan δ ratio than the borosilicate glass for the microwave frequency used. Additionally, the organic material should be such that the coating vaporizes at a temperature either in the same region or slightly lower than the temperature required for conventional thermal bonding of the plate 10 and the block plate 14. Photoresist may be used to form the coating.

[0038] The block 14 is prepared as described above in the first method. The block 14 is then placed over the plate 10, as described above in the first method, so that the planar surfaces 12,14 face one another and are slightly separated by the organic coating. The plate 10 and the block 14 are then placed, in this orientation, in the microwave furnace.

[0039] The microwave furnace is then operated. The microwave irradiation causes the organic coating to heat more quickly than the borosilicate glass of the plate 10 and the block 14. In turn, the organic coating heats the portion of the planar surface 12 on which the coating is provided and the overlying portion of the planar surface 16 of the block 14. When these portions of the surfaces 12,16 have been heated to a temperature suitable for thermal bonding of the portions, the organic coating vaporizes and the vapour escapes from between the surfaces 12,16. The vaporization of the organic coating brings the portions of the surfaces 12,16 into intimate contact and direct thermal connection of the portions occurs. For the most part, other than immediately adjacent the organic coating, the plate 10 and the block 14 remain at significantly lower temperatures than that required for thermal bonding.

[0040] The plate 10 and the block 14 are then cooled slowly to avoid cracking.

[0041] The chip-type chemical device formed by method 2 is shown in Figure 4. The connection of the portions of the planar surfaces 12,16 closes the first and second grooves 18 so as to form, respectively, two interconnecting channels 54, (channel corresponding to second groove not shown). As indicated in Figure 4, each channel 54 is defined by the corresponding groove 18 and a region of the planar surface 16 of the block 14. The first, second and third holes 40,42,44 form reservoirs in a similar manner to that described above for the first method, but the reservoirs are closed (with the exception of communicating with the channels 54) by the planar surface 12 of the plate 10.

[0042] It will be appreciated that various modifications may be made to the first and second methods. For example, whereas it is advantageous to provide the chromium coating 34 or the organic coating only on the portion of the planar surface 12 immediately surrounding the grooves 18,20 as this reduces the bulk temperatures of the plate 10 and the block 14 during connection, it is not essential to do this. Alternatively, the chromium coating 34 or the organic coating could be provided over the whole area of the planar surface 12 of the plate 10.

[0043] It is not necessary to use a coating at all. Other microwave heatable means may be used. For example, metal elements could be incorporated into the plate 10 so as to lie just below the portions of the planar surface 12 that surround the grooves 18,20. Alternatively, metal elements could be incorporated in a similar manner into the block 14. During microwave irradiation, the metal elements would heat appropriate portions of the planar surface 12 or the planar surface 16 so as to assist or effect thermal connection of the plate 10 and the block 14.

[0044] Alternatively, instead of the coatings, a microwave heatable membrane having an appropriate shape could be placed between the planar surfaces 12,16.

[0045] The microwave heatable means could also be a layer or layers of grease and dust, such as might be deposited by handling, on one or both of the planar surfaces 12,16.

[0046] Instead of being formed on the plate 10, the grooves 18,20 could be formed on the surface 16 of the block 14.

[0047] The plate 10 and the block 14 need not be formed of glass, they can be made of any suitable material (e.g. metal, plastic, silicon, quartz).

Method 3 - method of controlling liquid flow in a chemical device

[0048] In the third method, the chip-type chemical device produced by the first method and shown in Figure 3 is used to perform a chemical reaction, the microporous silica structure 36 controlling movement of liquids through the device.

[0049] A first liquid reagent is placed into the reservoir formed by the second hole 42 (see Figures 1, 2 and 3). The first liquid reagent passes along the second portion of the second channel until it contacts the microporous silica structure 36. The reagent is drawn into the microporous silica structure 36 by hydrostatic forces by applying either a negative pressure at hole 44 whilst sealing hole 40 or by applying a position pressure to hole 42 whilst sealing hole 40.

[0050] A second liquid reagent is then added to the reservoir formed by the first hole 40. The second liquid reagent enters the first portion of the second channel and passes to the junction 26 and to the microporous silica structure 36, again under hydrostatic pressure.

[0051] A volume of the second liquid reagent is then added to the reservoir formed by the third hole 44 and passes to the microporous silica structure 36

[0052] At this stage, the small size of the pores of the microporous silica structure 36 prevents the first and second liquid reagents flowing through the silica structure 36 in response to hydrostatic forces caused by heads of the liquids in the reservoirs. Although a small amount of mixing of the first and second liquid reagents may occur in the microporous silica structure 36, mixing of the liquid reagents is largely avoided. It will be appreciated that the ability of the microporous silica structure 36 to largely prevent mixture of the first and second liquid reagents, until it is desired to start the reaction by applying an electrical potential, is highly advantageous for some applications.

[0053] During the above procedure, as the liquid reagents pass through the channels, air is driven ahead of the reagents and passes through the silica structure 36.

[0054] The first and second liquid reagents now provide continuous electrical pathways between any two of the reservoirs. The reservoirs formed by the first and second holes 40,42 are connected to the positive electrode of a voltage generating device and the reservoir formed by the third hole 44 is connected to the negative electrode of the device. The device is then operated to generate a voltage.

[0055] The electrical potential generates electroosmotic forces in the first and second channels and in the microporous silica structure 36. The electroosmotic forces propel the first liquid reagent from the reservoir formed by the second hole 42 to the reservoir formed by the third hole 44 and propels the second liquid reagent from the reservoir formed by the first hole 40 to the reservoir formed by the third hole 44. The flow of each reagent can be either continuous or intermittent. Intermittent flow is achieved by switching the voltage on and off in the reservoir (hole 40 or 42) containing the reagent for which intermittent flow is required.

[0056] During this process, the reagents mix at the junction 26 and the mixture passes through the microporous silica structure 36 where the bound catalyst catalyses reaction of the reagents. The product is collected in the reservoir formed by the third hole 44.

[0057] As the product (which is a liquid) collects in the reservoir formed by the third hole 44, the head or height of the product above the silica structure 36 gradually increases. This in turn exerts an increasing hydrostatic force on the product urging the product to flow back through the silica structure 36 in the opposite direction to the electroosmotic flow described above. However, the microporous silica structure prevents such back flow of product due to capillary resistance. This allows chemical control under diffusion conditions to pertain in the second channel and throughout the silica structure 36.

[0058] The third method could also be performed using the chip-type chemical device produced by the second method.

<u>Method 4 - method of preparing a working solution of a substance at a desired concentration in a chemical device</u>

[0059] The fourth method allows a solution of a substance to be prepared at a desired concentration in a chemical device. The method may be used with a chip-type chemical devices of the types manufactured using the first and second methods. Normally, the fourth method will be used with chip-type chemical devices having more complex arrangements of interconnecting channels than those described in the first and second methods.

[0060] As shown in Figure 5, in a first embodiment of the fourth method, a porous solid substance 60, from which it is desired to make the working solution, is provided in a channel 61 of a chip-type chemical device having a plurality of channels. This may be done either by passing the substance through a hole in one of the members from which the device is formed or by positioning the solid substance in a groove before the members are connected together such that the connection closes the groove to form the channel containing the substance. The channel having the substance is narrow (generally having a width of 500μm or less). The substance 60 is fixed in the channel 61.

[0061] When it is desired to prepare the working solution, a solvent for the substance is passed through the channel 61 such that the solvent passes through the porous substance 60. As solvent passes through the substance, the solvent will dissolve the substance to form the working solution. In Figure 5, the arrow F1 indicates solvent flowing towards the substance 60 and the arrow F2 indicates the working solution flowing from the substance 60. The rate at which the solvent is passed through the substance determines the concentration of the substance in solution in the solvent that has passed through the porous solid substance. Hence, the rate of solvent flow is controlled to achieve a working solution of desired concentration.

[0062] The channel in which the substance is provided is sufficiently narrow so that dissolution of the substance is diffusion limited.

[0063] The working solution may be used as a reactant or as a calibration standard.

[0064] When the desired volume of the working solution has been prepared, the solvent can be drained from the channel holding the solid substance. If required, the process can be repeated. As dissolution is diffusion limited, subsequent working solutions of the same concentration can be produced by reproducing the rate of flow of the solvent.

[0065] It will be appreciated that the fourth method may be varied. For example, as shown in Figure 7, in a second embodiment of the fourth method, instead of using a porous solid, the substance used to make the working solution may be immobilized in a slow release gel 62. The working solution could be prepared by

bringing a predetermined volume of a solvent into contact with the slow release gel (indicated by arrow F5) and leaving the solvent in contact with the slow-release gel 62 for a predetermined duration during which the substrate dissolves to form the working solution. The working solution is then removed from contact with the gel (as shown by arrow F6). By controlling the duration of the contact between the solvent and the slow-release gel 62, working solutions of different concentrations may be prepared. This embodiment can also be performed with other forms, both porous and non-porous of substance to be dissolved.

[0066] Figure 6 shows a third embodiment of the fourth method. Here, a plug of non-porous solid 63 protrudes into the interior of a channel 61. Solvent is passed to the plug 63 (as indicated by arrow F3) and contacts the plug so as to dissolve solid from the plug 63 and from a working solution. The working solution is passed away from the plug (as indicated by arrow F4). This process can be a continuous flow process in which a continuous stream of working solution is produced. The concentration of dissolved solid will then be dependent on the rate of flow.

[0067] It will be appreciated that the four methods described above need not be used together. In particular, the third and fourth methods may be used, independently from one another, with chemical devices that are not manufactured by either the first or second methods. Also, the chemical devices manufactured by the first and second methods may be used to perform chemical reactions, analyses or separations without using the third or fourth methods.

Claims

1. A method of manufacturing a chemical device comprising, providing a first member (10) with a surface portion and a groove (18, 20) located at the surface portion, a second member (14) with a surface portion, and means (34) heatable by electromagnetic irradiation, positioning the members (10, 14) and the means (34) so that the means (34) lies between the surface portions, and heating the means (34) by electromagnetic irradiation to effect or assist linking of the surface portions by the means (34) so as to close the groove (18, 20) to form a channel (46).

2. A method according to claim 1, wherein the means is a coating (34) provided on one of the surface portions, said heating effecting or assisting bonding of the coating (34) to the other one of the surface portions.

3. A method according to claim 2, wherein the coating (34) is provided on the surface portion of the first member(10), the coating (34) lying adjacent to and on both sides of the groove (18, 20), the channel (46) being defined by the groove (18, 20), the coating (34) and a region of the surface portion of the second member (14).

4. A method according to claim 3, wherein the surface portion of the first member (10) is part of a planar surface (12) of the first member (10).

5. A method according to any one of claims 1 to 4, wherein the means (34) is composed at least partially by a metal.

6. A method according to claim 5, wherein the means (34) is composed of chromium.

7. A method of manufacturing a chemical device comprising, providing first and second members (10, 14) having respective surface portions, and means heatable by electromagnetic irradiation, positioning the members (10, 14) and the means relative to one another so that the means is positioned for providing localised heating of at least one of the surface portions on heating of the means by electromagnetic irradiation, irradiating with electromagnetic radiation so as to cause said localised heating, and connecting the surface portions together so that the surface portions cooperate to define a channel (54), the localised heating effecting or assisting said connection.

8. A method according to claim 7, wherein after said positioning and prior to said heating the means lies between the surface portions, the heating removing at least part of the means from between the surface portions.

9. A method according to claim 8, wherein said removal comprises vaporization of the means.

10. A method according to claim 8 or claim 9, wherein the means is a coating provided on one of the surface portions.

11. A method according to claim 10, wherein the coating is composed of an organic material.

12. A method according to claim 11, wherein the coating is composed of photo-resist.

13. A method according to any one of claims 7 to 12, wherein the first member (10) has a groove (18, 20) located at the surface portion of the first member (10), the channel (54) being defined by the groove (18, 20) and a region of the surface portion of the second member (14).

14. A method according to claim 13, when claim 13 is dependent on any one of claims 10 to 12, wherein the coating is provided on the surface portion of the

first member (10) and lies immediately adjacent the groove (18, 20) on both sides of the groove.

15. A method according to any preceding claim, wherein the means is heatable by microwave irradiation and said irradiation is irradiation with microwave radiation.

16. A method according to any preceding claim, wherein the members (10, 14) are formed of glass, silicon or quartz.

17. A method according to claim 16, wherein the members (10, 14) are formed of borosilicate glass.

18. A chemical device comprising a first member (10) with a surface portion and a groove (18, 20) located at the surface portion and a second member (14) with a surface portion, the surface portions being linked by an electromagnetic irradiation heatable layer (34) such that the groove (18, 20) is closed to form a channel (46).

19. A chemical device according to claim 18, wherein the channel (46) is defined by the groove (18, 20), the layer (34) and a region of the surface portion of the second member (14).

20. A chemical device according to claim 18 or claim 19, wherein the members (10, 14) are composed of glass, silicon or quartz, preferably borosilicate glass.

21. A chemical device according to any one of claims 18 to 20, wherein the layer (34) is composed at least partially of a metal.

22. A method of controlling liquid movement in a chemical device comprising a porous structure (36, 53), the method comprising applying an electrical potential to generate an electroosmotic force in the porous structure (36, 53) so as to propel a liquid through the porous structure (36, 53), and using the porous structure (36, 53) to resist or prevent flow of a liquid through the porous structure (36, 53) in response to hydrostatic force.

23. A method according to claim 22, wherein the liquid propelled through the porous structure (36, 53) and the liquid acted on by the hydrostatic force are the same, said propelling of the liquid and said resisting or preventing of flow of the liquid in response to hydrostatic force occurring simultaneously.

24. A method according to claim 23, wherein the electroosmotic flow propels the liquid in a first direction and the hydrostatic force urges the liquid to flow in a second direction opposite to the first direction.

25. A method according to claim 22, wherein said propelling and said resisting or preventing do not occur simultaneously.

26. A method according to any one of claims 22 to 25, wherein the chemical device comprises a first part (10; 10 + 34) having a groove and a second part (14) having a surface (16), a region of the surface (16) closing the groove so that the groove and the region together define a channel (46, 54), the porous structure (36, 53) being located in the channel (46, 54).

27. A method according to any one of claims 22 to 26, wherein the porous structure (46, 54) is composed of a silica compound.

28. A method according to claim 27, wherein the porous structure (46, 54) was formed by reacting formamide and potassium silicate.

29. A method according to any one of claims 22 to 28, wherein the device has a reservoir (40, 42, 44), said hydrostatic force being generated by a head of liquid above the porous structure (46, 54) in the reservoir (40, 42, 44).

30. A method according to any one of claims 22 to 29, wherein the device is a chip-type chemical device.

31. A method according to claim 26, or any claim dependent on claim 26, wherein the first part comprises a member (10) having a surface (12) and a coating (34) provided on the surface, the groove interrupting the coating (34) and extending into the member (10).

32. A method according to any one of claims 22 to 31, wherein a catalyst is bound to the porous structure (36, 53).

33. A method of preparing a working solution of a substance at a desired concentration in a chemical device comprising, providing a substance in a soluble form in a chemical device, contacting the substance with a solvent for the substance in the device, and controlling said contact between the substance and the solvent so as to produce a working solution of the substance in the solvent at a concentration dependent on said control.

34. A method according to claim 33, wherein said contacting comprises moving the solvent past the substance so as to contact the substance, said controlling of the contact comprising controlling the rate of movement of the solvent.

35. A method according to claim 33, wherein said con-

tacting comprises contacting a volume of the solvent with the substance and leaving the solvent and the substance in contact for a controlled duration before separating the substance and the solvent.

36. A method according to any one of claims 33 to 35, in which after said contacting, the solvent and the substance are separated, the substance then being contacted with a further solvent for the substance, said contact between the substance and the further solvent being controlled so as to produce a working solution of the substance in the further solvent at a concentration dependent on said control of the contact between the substance and the further solvent.

37. A method according to claim 36, wherein the further solvent has the same composition as the first mentioned solvent.

38. A method according to any one of claims 33 to 37, wherein the substance is a porous solid.

39. A method according to claim 38, when dependent on claim 34, wherein the solvent is passed through the substance.

40. A method according to any one of claims 33 to 37, wherein the substance is a gel or immobilized in a gel.

41. A method according to any one of claims 33 to 40, wherein the working solution of the substance in the solvent is then used in the chemical device for calibration.

42. A method according to any one of claims 33 to 40, wherein the working solution of the substance is then reacted in the chemical device.

43. A method according to any one of claims 33 to 42, wherein the chemical device is a chip-type chemical device.

Fig.1.

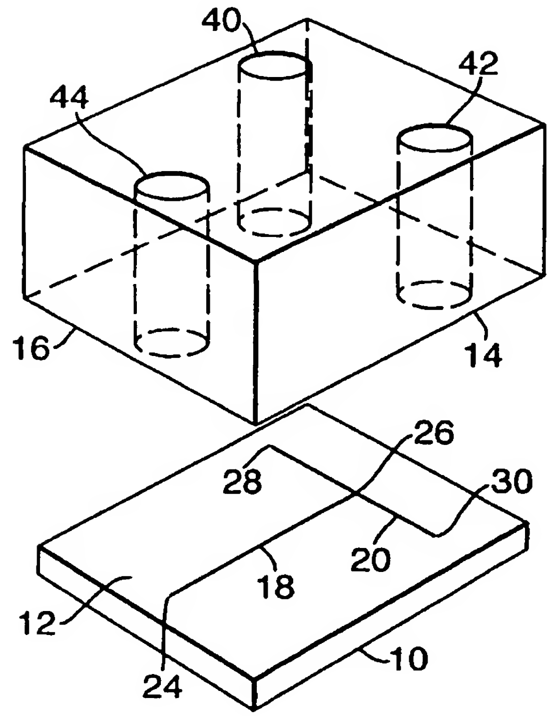

Fig.2.

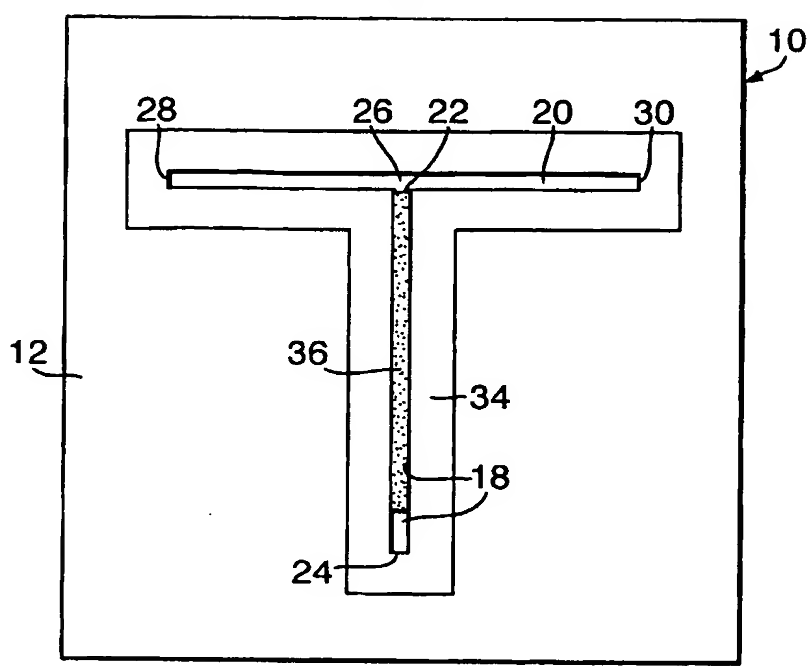

Fig.3.

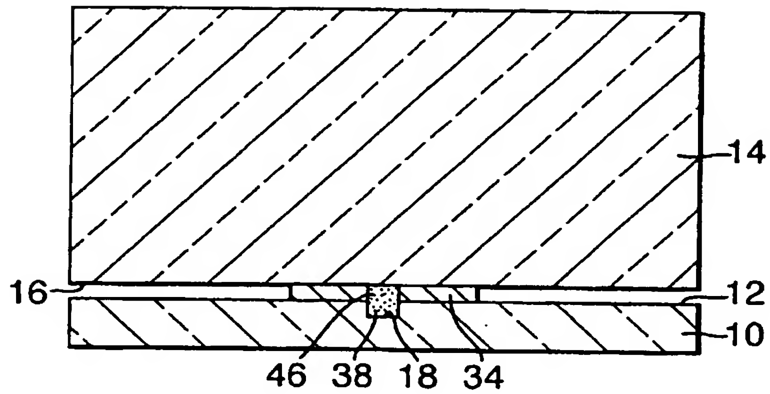

Fig.4.

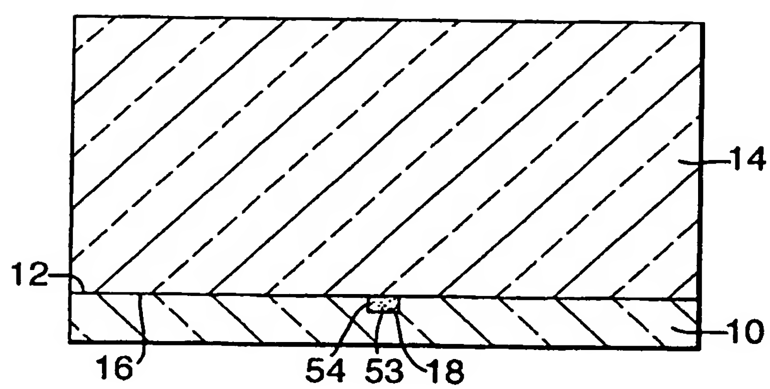

Fig.5.

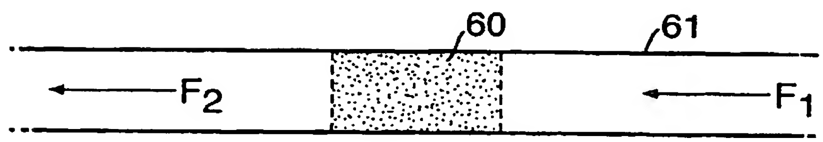

Fig.6.

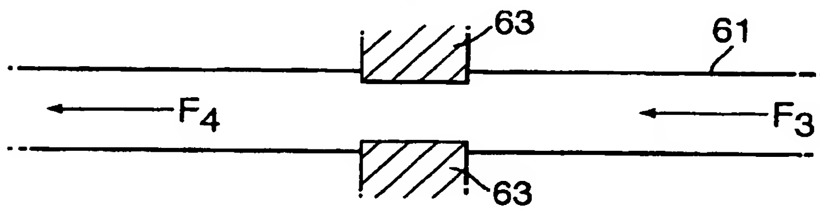

Fig.7.